

A survey of the Critically Endangered Spoon-billed Sandpiper *Eurynorhynchus pygmeus* in Bangladesh and key future research and conservation recommendations

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As the scale of the decline in the Critically Endangered Spoon-billed Sandpiper has become apparent, the urgency to understand the size and distribution of the remaining population in order to identify key threats and implement targeted conservation actions has intensified. Bangladesh has been recognised as an important non-breeding range state since the largest single flock of 202 individuals ever recorded was found at Moulevir Char in 1989. Annual winter totals have been considerably lower in recent years as survey attention has focused on Myanmar. We conducted surveys in coastal Bangladesh between 6 March and 8 April 2010 to determine the continuing importance of Bangladesh for wintering Spoon-billed Sandpiper, gather information about the species's foraging ecology and habitat preference, and assess potential threats. A minimum 49 Spoon-billed Sandpipers were seen at three locations. Foraging birds displayed a marked preference for firm sandy intertidal mudflats with a thin layer of soft mud collecting in ripples, spending 98% of their time feeding within small pools left by the receding tide, singly or in small groups. Shorebird hunting, recently identified as a significant threat to Spoon-billed Sandpiper in Myanmar, was found in some areas. Our preliminary surveys yielded variable catch rates and overall prevalence, but suggest that hunting may have decreased locally since advocacy work was conducted in 2009. We discuss other plausible threats to Spoon-billed Sandpiper and their intertidal habitats, concentrating on large-scale infrastructure development and widespread small-scale habitat conversion. Our surveys covered only a fraction of potentially suitable intertidal habitats and were largely confined to known sites. We therefore list priority research actions designed to elucidate the true status of Spoon-billed Sandpiper in Bangladesh and allow priorities to be set for conservation actions identified in the species's action plan.

INTRODUCTION

The Spoon-billed Sandpiper *Eurynorhynchus pygmeus* is a migrant shorebird that breeds in the Russian Arctic centred on the coast of the Chukotsk Peninsula (e.g. Dixon 1918, Tomkovich *et al.* 2002). It is known to winter in intertidal habitats in South-East and South Asia from the Minjiang estuary, south-east China, west to the Bay of Bengal, where the largest wintering concentrations have been recorded both historically and in recent years (BirdLife International 2001, Zöckler & Bunting 2006, Zöckler *et al.* 2010). A rapid deterioration in the conservation status of the Spoon-billed Sandpiper was first detected in 2000 when breeding-season surveys of sites monitored during the 1970s indicated that a marked decline in the population had taken place (Tomkovich *et al.* 2002). This decline has been tracked during subsequent summer surveys in Russia between 2000 and 2009 (see Zöckler 2003, Syroechkovski 2005, Syroechkovski & Zöckler 2008, Syroechkovski & Zöckler 2009). In response, the species was uplisted from Vulnerable to Endangered on the IUCN Red List in 2004, and then again to Critically Endangered in 2008 (BirdLife International 2009). Targeted efforts to gather supporting data from the wintering grounds began with a survey of the Indian Sunderbans (though this failed to record Spoon-billed Sandpiper) in 2005 (Zöckler *et al.* 2005) followed by a survey in Bangladesh deploying three teams in January 2006 that recorded 11 individuals (Zöckler & Bunting 2006). In January of 2008, 2009 and 2010 exploratory surveys identified a significant wintering population at several coastal sites in Myanmar (Zöckler & Htin Hla 2009, Zöckler *et al.* 2010). These concerted survey efforts since 2000 have informed a global population estimate of 120–250 breeding pairs with an

estimated total population of 500–800 individuals (C. Zöckler pers.comm. 2010).

Bangladesh retains the record for the highest single count of Spoon-billed Sandpipers—202 birds in 1989 from Moulevir Char, a small island in the vast Lower Meghna delta (Bakewell & Howes 1989a, 1989b in BirdLife International 2001). The species was recorded as early as the 1920s (BirdLife International 2001) and regularly from the late 1980s through the 1990s (Thompson *et al.* 1993, Thompson & Johnson 2003) right around Bangladesh's coastline from outer islands south of the Sunderbans in the west, through the Lower Meghna delta and south-east to Teknaf on the border with Myanmar (BirdLife International 2001, BirdLife International 2009). Although the known breeding distribution has been relatively well monitored since the 1970s (Tomkovich *et al.* 2002), the core wintering areas remained largely unknown until very recently. The history of the species in Bangladesh hinted at the importance of the Bay of Bengal (BirdLife International 2001), since confirmed through recent searches in Bangladesh and Myanmar listed above. However, the reporting rate in Bangladesh declined through the 1990s (Thompson & Johnson 2003), but whether this was a reflection of the inferred population declines observed on the breeding grounds or a reduction in search effort, or both, is unclear. Perhaps partly in response to a return of only 11 Spoon-billed Sandpipers during the first targeted search for this species in Bangladesh in 2006 (Zöckler & Bunting 2006) attention has shifted to Myanmar in the last three winters in a successful effort to discover a part of the 'missing' wintering population.

Recent records from Bangladesh including 21 Spoon-billed Sandpipers seen on Sonadia Island, Cox's Bazar District, in February 2006 (M. Z. Islam in Zöckler &

Bunting 2006) and 15 at Damar Char, Greater Noakhali District in April 2008 (Zöckler 2008), hinting at the continuing importance of Bangladesh for the species in the non-breeding season. After discovering the importance of the country for shorebirds, particularly Spoon-billed Sandpiper, Bakewell & Howes (1989a) recommended a full coastal survey of Bangladesh. This recommendation remains paramount over 20 years later, and refining the global population estimate and reducing its confidence limits through continued surveys in Bangladesh and Myanmar is a stated research priority (Zöckler *et al.* 2008, BirdLife International 2009). JB, AL and RM joined colleagues SUC and EUH between 6 March and 8 April 2010 in Bangladesh, aiming to (1) assess shorebird survey effort to date, (2) record numbers of Spoon-billed Sandpipers and other threatened waders at known and previously unsurveyed sites, (3) gather new data about foraging ecology, (4) improve our understanding of potential threats to priority shorebirds and their habitats, and finally (5) do all of the above in March, two months later than previous midwinter counts in January, in order to provide supporting evidence for a hypothesis that Spoon-billed Sandpipers may move north into the Bay of Bengal before migrating overland to the Yellow Sea (supported by two historic records of Spoon-billed Sandpiper from Assam: Saikia & Bhattacharjee 1990).

METHODS

Shorebird surveys

In the absence of a predictive model to determine the likely non-breeding distribution of Spoon-billed Sandpipers, potentially suitable sites were identified from satellite images freely sourced from Google Earth, the Landsat Programme (<http://landsat.gsfc.nasa.gov/>), ASTER (<http://glovis.usgs.gov/>) and Flash Earth (<http://www flashearth.com/>) following guidelines detailed in Bunting & Zöckler (2009). Suitable sites were then ground-truthed and shorebird populations assessed following methods for counting non-breeding waders outlined in Bibby *et al.* (2000). Shorebirds were surveyed in three main areas: around Sonadia Island, Cox's Bazar District; at the Feni estuary and Hatiya Islands of Greater Noakhali District; and in the Lower Meghna delta around Bhola District. Additional short surveys were undertaken at the Sangu estuary and Bodur Makam, Teknaf.

Spoon-billed Sandpiper habitat preferences and foraging ecology

At foraging sites we took basic notes on substrate type (sand, mud, sand-mud mix) and substrate-depth (no mud, shallow mud = <15cm, deep mud = >15 cm). Pearson's Chi-square test was used to test the null hypothesis of uniform distribution of foraging Spoon-billed Sandpiper between substrate types and depths. This survey was predominantly focused on covering as many disparate areas as possible, which left relatively little time for prolonged observations of feeding birds to gather detailed data on foraging ecology. Therefore HD digital video recordings were taken using a Sony DSC-W220 digital camera handheld to a Swarovski ATM 65 HD Scope & 30 WA eyepiece for subsequent analysis. Sediment samples were collected at survey sites to allow future analysis of particle size, nutrient content and heavy metal content.

Hunting interviews

To investigate the threat of hunting to shorebirds we carried out opportunistic semi-structured interviews following guidelines outlined by FAO (1990) and in consultation with R. F. A. Grimmett. These were designed to assess (1) numbers of trappers, (2) number of trapping locations, (3) frequency of hunting, (4) abundance and composition of harvested species, (5) methods used to hunt shorebirds, (6) which socio-economic group(s) are trapping, (7) whether hunters have alternative income sources, (8) if hunting is for subsistence use or trade, (9) if trapping rights exist, (10) the value of the trapping/trade. To assist these interviews, awareness-raising materials were carried and distributed, including identification cards illustrating local wader species. These were primarily used to identify species that interviewees recognised and/or were hunted. Interviewees received Royal Society for the Protection of Birds (RSPB) pin badges as thanks for participating.

RESULTS

Shorebird surveys

In total a minimum of 49 Spoon-billed Sandpipers (hereafter SBS) were recorded, comprising 25 individuals at Sonadia, 23 at Damar Char and 1 at Teknaf (Table 1). Counts at Sonadia and Teknaf probably comprised all or almost all the SBS present, but at Damar Char the count may only have represented a fraction of the wintering or passage population. At this site the main high-tide roost was inaccessible during our survey and birds may have dispersed at low tide to other foraging grounds in three cardinal directions. Taken together, our counts alone represent the highest annual total of SBS in Bangladesh since the 257 birds recorded in January 1989 and 'about 100' seen during Asian Waterbird Census counts in 1992 (Thompson *et al.* 1993). Although it is tempting to speculate that the high numbers recorded during our survey might pertain to northbound passage birds, without a full winter survey it is impossible to confirm this hypothesis. Our failure to find SBS (or other shorebirds of conservation concern) at the Sangu estuary suggests that this site is not regionally important but may yet prove to hold small numbers of these key species on passage, while at the Feni estuary coverage was inadequate during this survey to draw firm conclusions. We recorded significant numbers of other globally threatened shorebird species (Table 1) including the highest counts of Asian Dowitcher *Limnodromus semipalmatus* and Great Knot *Calidris tenuirostris* ever recorded in Bangladesh and the highest count of Spotted Greenshank *Tringa guttifer* since 1988 (Thompson *et al.* 1993, Thompson & Johnson 2003, P. Thompson pers. comm. 2010). These findings are provided for general interest here but will be the focus of a forthcoming more detailed paper.

Spoon-billed Sandpiper habitat preferences and foraging ecology

Of the 12 main foraging sites (i.e. not roosting sites or saltpans) where we recorded shorebird numbers, substrate type and depth (Table 1), SBS was only recorded at sites with a mixed substrate composed of a firm sand base-layer and a soft mud component collecting between sand ripples ($\chi^2=11.99$, $df=1$, $P<0.0001$). Significantly we did

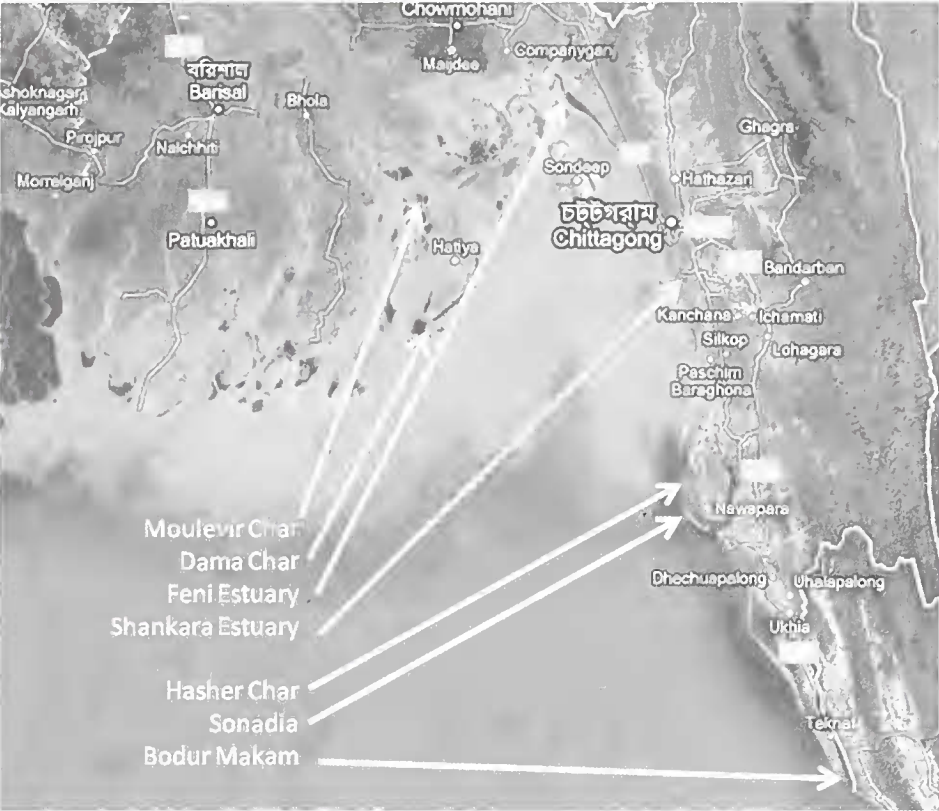


Figure 1. Sites visited during Spoon-billed Sandpiper surveys in March–April 2010. Base layer © Google Earth.

Table 1. Habitat characteristics and abundance of shorebirds of conservation concern. Detailed findings relating to species other than SBS will be the subject of a forthcoming paper.

Site name	Coordinates	Date	Site description	Mud depth	Spoon-billed Sandpiper (CR) <i>Enhyalorhynchus pygmaeus</i>	Spotted Greenshank (EN) <i>Tringa guttifer</i>	Asian Dowitcher (NT) <i>Limnodromus semipalmatus</i>	Black-tailed Godwit (NT) <i>Limosa limosa</i>	Eurasian Curlew (NT) <i>Numenius arquata</i>	Great Knot (VU) <i>Calidris tenuirostris</i>	Estimated shorebird total
Tajiakata	21.4959°N 91.9154°E	08/03/2010	mud	shallow	–	–	–	–	15	–	
Belekadia	21.5311°N 91.8425°E	08/03/2010	high-tide roost	n/a	–	–	–	–	–	5	600
Belekadia	21.5311°N 91.8425°E	09/03/2010	mud	deep	–	–	–	–	11	–	110
Kaladia	21.5546°N 91.8635°E	09/03/2010	sand-mud mix	shallow	20	4	–	–	39	2	1,200
Baradia	21.5434°N 91.8932°E	10/03/2010	salt pan	n/a	–	–	–	–	–	–	150
Kaladia	21.5512°N 91.8632°E	10/03/2010	mud	deep	–	–	–	–	35	256	700
Hasher Char	21.6049°N 91.8491°E	10/03/2010	mud	deep	–	2	–	52	40	5	1,100
Hasher Char	21.6049°N 91.8491°E	11/03/2010	mud	deep	–	24	–	70	20	170	2,350
Kaladia	21.5546°N 91.8635°E	11/03/2010	sand-mud mix	shallow	23	2	–	–	12	45	450
Halodia	21.5466°N 91.8548°E	11/03/2010	sand-mud mix	shallow	2	–	–	–	15	20	300
Belekadia	21.5311°N 91.8425°E	12/03/2010	mud	deep	–	–	–	–	5	3	80
Mog Char	21.4724°N 91.9128°E	12/03/2010	mud	deep	–	–	–	–	–	–	60
Shangu estuary	22.1136°N 91.8443°E	13/03/2010	mud	shallow	–	–	–	–	–	–	840
Feni estuary	22.8166°N 91.4142°E	16/03/2010	mud	deep	–	–	–	–	2	–	720
Char Kandia	22.8155°N 91.4070°E	17/03/2010	mud	deep	–	–	–	–	–	–	250
Char Fakura	22.7776°N 91.3662°E	17/03/2010	mud	deep	–	–	–	–	3	–	220
Feni estuary/ Char Kandia	22.7968°N 91.4234°E	18/03/2010	mud	deep	–	–	–	–	17	–	770
Feni estuary	22.7768°N 91.4381°E	18/03/2010	mud	shallow	–	–	–	–	–	–	55
Nijhum Dweep	22.0741°N 90.9772°E	26/03/2010	mud	deep	–	–	–	–	2	–	350
Damar Char	22.0236°N 91.0584°E	27/03/2010	high-tide roost	n/a	–	–	–	9,000	150	–	34,100
Damar Char	22.0340°N 91.0560°E	28/03/2010	sand-mud mix	shallow	19	5	34	–	–	26	
Damar Char	22.0236°N 91.0584°E	28/03/2010	high-tide roost	n/a	–	–	–	8,500	75	–	34,900
Damar Char	22.0340°N 91.0560°E	28/03/2010	sand-mud mix	shallow	23	14	12	–	–	8	
Bodur Makam	20.7517°N 92.3351°E	04/04/2010	sand-mud mix	shallow	1	–	–	–	–	–	280
Kaladia	21.5546°N 91.8635°E	05/04/2010	sand-mud mix	shallow	3	–	–	–	13	–	185
Belekadia	21.5311°N 91.8425°E	08/03/2010	high-tide roost	n/a	–	–	2	8	23	200	930

not find this species in areas of deep (>15 cm) mud ($\chi^2=5.99$, $df=1$, $P<0.025$), despite the presence of thousands of individuals of other shorebird species at many of these sites. Detailed analysis of the biochemical constitution of these substrate types is beyond the scope of this paper and will be dealt with separately. A preference for mudflats with a sand/mud mix has previously been documented in SBS not only in Bangladesh (Thompson *et al.* 1993) but also in Myanmar (N. Clark pers. comm. 2010), Thailand (D. Sibley *in litt.*), Vietnam (Pedersen *et al.* 1998) and Japan (BirdLife International 2001).

Foraging birds spent c.98% of their time (based on 10 minutes 47 seconds of video footage) feeding within small pools left by the receding tide, both at the tide edge and up to 600 m from the open sea. Apart from when tidal conditions produced concentration effects, birds typically foraged singly or occasionally in groups of 2–6, or with other small waders such as Red-necked Stints *Calidris ruficollis*. Videos obtained at Sonadia (SOM 1. <http://tiny.cc/kid9h>) and Damar Char (SOM 2. <http://tiny.cc/kz81q>) document their predominantly solitary feeding habits and preference for such small pools. We found the 'hyperkinetic' foraging technique of SBS to be an excellent aid to their identification at long range—constantly running around, typically with head down (and with apparently reduced vigilance relative to other calidrids, although some bird species actually have a surprisingly good field of view behind their heads, so they can feed, head down, while maintaining vigilance; in the case of SBS, they may feed alone or widely spaced to guarantee a good view of attacking predators: D. Buckingham *in litt.* 2010). Typically birds foraged for food by wading around rapidly in shallow water that did not reach tibial height

(1–3 cm) and appeared to use the bill as a shovel, inserting it into the substrate and extracting prey items from underneath submerged mud (Plate 1a & b). Such a feeding strategy would permit them to take both marine epifauna and infauna (Sutherland *et al.* 2000). These shovelling motions were predominantly directed to the front, but sometimes also sideways (Plate 1c; see Swennen & Marteijn 1988, Pedersen *et al.* 1998). Assessing intake rates was difficult, as swallowing movements (Plate 1d) were never conspicuous and food items too small and rapidly processed to be identifiable, but some successful feeding bouts are evident in the video (e.g. SOM 2: 4 minutes 44 seconds). We also observed SBS processing larger food items on four occasions, which required more extensive mandibulation for 1–2 seconds, but were unable to ascertain their identity. It appeared that some prey detection or at least 'shovelling site selection' was undertaken visually, with birds walking on 'tip toes' with neck outstretched (e.g. SOM 2: 5 minutes 35 seconds). Some agonistic interactions were observed with birds chasing Red-necked Stints *Calidris ruficollis* and being displaced by Red-necked Stints, Lesser Sand Plover *Charadrius mongolus* and Sanderling *Calidris alba*.

Hunting interviews

We were able to speak with a cross section of different inhabitants at Sonadia, including one former bird hunter, a locally employed NGO worker and local fishermen. A former bird hunter (active <5 years ago) indicated that previously 10–20 people in his village on Sonadia were involved in bird hunting but that this number had fallen to just 2–3 individuals/village after anti-hunting campaigns by local NGOs. However, it was also claimed that there

Plate 1. Montage of images of a feeding Spoon-billed Sandpiper; see text for details (A. Lees).



were still 25–30 trappers active across a broader region encompassing five villages, many of which fell outside the influence of awareness campaigns. The interviewee reported that circa 500 birds per year per hunter were taken and sold locally with current prices per bird at circa 80–100 BDT (\$US1.1–1.7) for large species such as Eurasian Curlew *Numenius arquata*, with small sandpipers *Calidris* and plovers *Charadrius* valued at just 10 BDT (\$0.1). There is apparently no longer an open market as hunting is recognised as being illegal and birds are only sold locally. The local NGO worker reported substantially higher hunting activity, with an estimate of 100 hunters (c.20/village) out of a total population of 7,000 people from six villages. However, he also indicated that the hunters would be happy to stop catching birds if alternative income sources could be found. Hunting is predominantly carried out using monofilament nets set at high-tide roosts, often with live decoys tethered to the ground. A group of villagers interviewed at a different village on Sonadia also indicated that hunting was formerly more frequent and that visiting professional bird hunters targeted a high-tide roost that could yield 500 birds in a single catch with coordinated flushing. They reported no such activity in the last two years after campaigns by the Coastal and Wetland Biodiversity Management Project (CWBMP).

DISCUSSION

Minimum totals of 1, 23 and 25 Spoon-billed Sandpipers at three disparate coastal sites in March and April 2010 provide clear evidence that Bangladesh remains critically important for the species. According to the most recent extrapolation from numbers of birds in the breeding grounds the global population is estimated at 500–800 individuals (C. Zöckler pers. comm. 2010). Based on this estimate, this survey may have observed up to 10% of the global population. In 2010 an estimated 236–286 SBS were recorded on the wintering grounds (assuming there was no double-counting between different range states), in Bangladesh (49), Myanmar (150–200 birds in the Bay of Martaban, 14 at Nan Thar island and 1 in the Irrawady Delta: Zöckler *et al.* 2010), Thailand (10) and China (12) (Bunting & Zöckler 2010). It follows that the wintering grounds for very roughly 50–70% of the global population are therefore being overlooked. The estimates and extrapolations made above are largely supposition: they may vary considerably but the data are not available to ascertain accurate figures. We are confident, however, that Bangladesh offers a relatively cost-effective opportunity for further surveys to identify important new sites (i.e. with no recent records) that may support a proportion of the ‘missing’ individuals.

Threats to shorebirds in Bangladesh

Sonadia Island is a globally important site for SBS and other threatened shorebirds, dolphins and marine turtles. It is therefore considered ecologically important by the government; in 1999 it was declared as an Ecologically Critical Area (ECA) under the Bangladesh Environment Conservation Act, 1995 (Zöckler 2009). The site is not recognised as an Important Bird Area (IBA) (BirdLife International 2004) but should qualify during a currently planned revision of Bangladesh’s IBAs (P. Thompson *in litt.* 2010). The CWBMP has worked to strengthen

conservation planning and awareness and to develop alternative livelihoods for local people in the ECAs of Sonadia and Teknaf area since 2005, but it ends in 2010. A feasibility study by Pacific Consultants International for the construction of a deep-water port in Bangladesh has identified Sonadia Island as the priority site, with construction expected to begin in December 2010 (Mahmud 2009), but it is not yet clear if this project is to go ahead and more recently there have been reports of plans for other sites for port development. If it does go ahead at Sonadia Island this development funded by a public-private partnership will almost certainly have a dramatic and deeply negative impact on a whole suite of threatened species.

As well as the proposed deep-sea port at Sonadia there have been long-term plans dating back to the 1980s for several cross-dams, originally proposed under the Land Reclamation Project of the Bangladesh Water Development Board with technical cooperation from the Netherlands, particularly for a cross dam between Hatiya and Nijumdip in Noakhali District (P. Thompson *in litt.* 2010). Smaller cross-dams have already been used to reclaim land and establish polders along the Noakhali coastline, and proposals have also been made to connect Sandwip with the main Noakhali coastline (Rashid 1989). These plans reportedly re-emerge periodically (P. Thompson pers. comm.). If implemented, they would threaten a vast area of the least explored (and potentially most significant) intertidal habitats in the Lower Meghna delta. There are no immediate plans for this development but changes to the status quo should be monitored.

Localised conversion of intertidal habitats to salt pans, shrimp-ponds and mangrove plantation additively impact large areas of Bangladesh’s coastline. The extent to which these processes affect habitats is dependent on the overall rate of conversion in one of the fastest accreting systems on earth. If conversion is slower than mud/sandflat creation the impact on shorebirds is likely to be minimal, particularly if shorebirds are adapted to move between these ephemeral habitats as areas are rendered unsuitable by succession and others become available. However, if rates of conversion are faster than accretion of new habitat, then conversion may represent a threat within Bangladesh. It is possible that the sandy substrates selected by SBS are relatively stable compared to soft mud deposits. If that is so, this provides a greater need to protect existing sites from development, on the assumption that suitable sites are limiting and may not be replaced quickly. Aquaculture of *bagda* shrimp *Penaeus monodon* was expanded from 51,812 ha in 1983–1984 to 142,110 ha in 1993–1994 (Zöckler *et al.* 2008). Between 1960–61 and 1999–2000, 142,835 hectares of mangrove were planted (Bangladesh Forest Department 2010) and this rate may have increased since; mangrove plantation is a tool for stabilising newly accreted areas and for the protection of the hinterland in cyclonic storms, and is strongly advocated by government and development NGOs in Bangladesh; but the biodiversity impacts are unknown. The area of intertidal habitat in Bangladesh remains absolutely vast, and although SBS appears to utilise a very specific and apparently localised substrate, habitat availability is probably unlikely to be limiting carrying capacity. However, given the paucity of information on the SBS prey-base and the exact use of its morphologically divergent bill, we should not be complacent. It is plausible

that only certain prey types might be affected by, e.g., climate change, sea-level changes or marine pollution, and this species may be adversely affected if there is no alternative prey, or if bill morphology precludes prey-switching (Durell 2000).

We gathered limited anecdotal data through semi-structured interviews to supplement previous assessments of hunting pressure on shorebirds, particularly around Sonadia where an awareness-raising campaign was implemented in 2009. Shorebird hunting was reported to have declined recently, following the ban on international trade in wild birds and local people's perception of the risk of contracting zoonotic infections whilst handling wild birds (e.g. avian influenza). Moreover, an awareness-raising campaign carried out by MarineLife Alliance through the UNDP/GEF-funded CWBMP may have helped reduce local hunting pressure (Zöckler 2009). Given limited past surveys it remains unclear whether the hunting threat in Bangladesh represents the clear and present danger that it evidently poses to shorebirds in Myanmar (Zöckler *et al.* 2010b) and elsewhere (Lees & Bird in prep.). However, considering that we encountered shorebird hunters, including individuals who claimed to have caught SBS historically then it must be taken seriously. The Bangladesh Wildlife Preservation Order 1973 protects circa 70% of the country's bird species including SBS (Siddiqui *et al.* 2008). The act has recently been amended (awaiting final approval and will be released shortly), and will protect all wild birds except House *Corvus splendens* and Large-billed Crows *C. macrorhynchos*.

Plausible threats to shorebirds and intertidal habitats in Bangladesh that were not discussed or observed during this survey are rural development, particularly on sensitive coastal *chars*, pollution, hydrological regime change and climate change (for thorough treatment of these threats see Zöckler *et al.* 2008).

Recommendations

The Spoon-billed Sandpiper faces real and potential threats in the breeding, passage and wintering parts of its range: it has poor breeding productivity, perhaps owing to nest predation and bad weather, and there are concerns that breeding habitat in the south of its range is no longer suitable owing to climate change; key stopover sites on migration, particularly intertidal wetlands in the Yellow Sea, have been converted for urban and industrial development; and in the wintering areas the main documented threat is hunting with waders regularly trapped in nets (Zöckler *et al.* 2008, Syroechkovski *et al.* 2009, Zöckler *et al.* 2010b). Conservation actions proposed or already underway (see Zöckler *et al.* 2008) are helping to address a number of these threats and should be encouraged. However, the completeness of this list of threats, and their relative impacts in the past and present on the global population, remain poorly understood. Prioritising conservation actions is further hampered by the absence of robust population size and trend estimates; the urgency of one action versus another is contingent on understanding the size of the remaining population.

The surveys presented here did not fulfil the recommendation of Bakewell & Howes (1989a) for a full coastal survey of Bangladesh. This remains a research priority, so we outline below some suggestions for future work in or relating to Bangladesh. These are designed to

supplement rather than repeat those identified in the current action plan for Spoon-billed Sandpiper (Zöckler *et al.* 2008), so future conservation planning needs to consider the ideas detailed in the action plan alongside those that follow.

Research actions

- A thorough spatiotemporal analysis of survey effort in Bangladesh is required to examine the survey frequency and duration at suitable coastal sites and intertidal habitat types surveyed, coupled with presence/absence and abundance data for SBS. This should permit more robust analysis using Geographical Information Systems (GIS) of habitat suitability, shed light on any movements during the non-breeding season, and (if sufficient data are available) an assessment of wintering population size and population trends for Bangladesh.
- Further SBS surveys coupled with a thorough ground-truthing of habitat quality might allow habitat choice to be effectively modelled and thus indicate potential priority sites for future survey effort. This exercise is dependent on high-resolution images of coastal South and South-East Asia at low tide but previous studies have indicated that satellite imagery can be used to predict grain size and benthic invertebrate distributions (Wade & Hickey 2008). Alternatively/in addition to this exercise accessing shipping data, if available, that models sediment accretion/erosion around Bangladesh's coastline could shed light on how habitats have changed over time (e.g. why sites like Moulevir Char are apparently less suitable for SBS now than when 202 were recorded in 1989). It could also reveal potential new search sites in recently accreted areas. This recommendation is based on the supposition that port developers and the mainstream shipping industry collect such data.
- If GIS analysis cannot effectively detect suitable habitat, then an 'eye-balling' of satellite imagery may help identify potentially suitable sites (Bunting & Zöckler 2009), although this technique is not without its limitations: examination of Google Earth by eye reveals apparently similar habitats around Sonadia Island which when ground-truthed vary radically in their suitability for SBS. Overall, however, in the absence of anything more effective we believe this remains a useful tool.
- Aerial surveys using a fixed-wing aircraft in January (and ideally, although of lower priority, repeated in March) could rapidly survey the entire coastline. If feasible, this would be the most effective method for identifying wader concentrations and potentially suitable wintering sites that could then be searched for SBS (see e.g. Clark *et al.* 1993, Engilis *et al.* 1998, Warnock *et al.* 1998). However, the specialisation of SBS to feeding within a particular substrate type raises the possibility that they could occur away from wader concentrations and render aerial surveys ineffective, but this may not be the case as SBS was always significantly outnumbered by commoner species utilising the same substrate type. Indeed, the converse is likely: many sites with high-wader concentrations may prove to be inappropriate for SBS.
- Boat-/land-based surveys are needed of all key sites (e.g. historical point localities, sites identified on satellite images and sites identified during aerial

surveys) in January and March 2011 to provide an accurate population estimate and identify hotspots for longer-term monitoring of SBS populations.

- After an initial investment to identify key shorebird/SBS sites and habitat, monthly monitoring of key sites and at least annual monitoring of all sites with recent records offers the potential to improve knowledge of local and regional movements, timing of migration and population trends. These aims would be abetted by a sample of the population being colour-ringed. However, any catching of SBS in Asia risks acting as a training exercise for local hunters in effective means for capturing waders, and should first consider hunting pressure and the need for education and awareness raising programmes as a precursor. Capturing individuals for colour-ringing would also provide an opportunity to undertake stable isotopic analyses to determine the likely summer breeding ground of this wintering subpopulation. Furthermore sexual dimorphism in bill measurements of SBS (N. Clark *in litt.* 2010) would allow the collection of data to assess whether there are any spatial differences in wintering locations in different sexes as has been observed in other calidrine waders (e.g. Sutherland *et al.* 2000).

Conservation actions

- Collaboratively the proposal to build a deep-water port at Sonadia needs addressing. At the very least we would advocate a thorough environmental impact assessment, the results and recommendations of which should be adhered to. A wider campaign to raise awareness of the potentially negative impacts of this development should also be considered.
- Presently only 7% of sites where SBS has been recorded in Bangladesh are designated IBAs (Zöckler *et al.* 2008) and none of the important coastal areas east of the Sundarbans is a designated Ramsar site. The planned revision of Bangladesh's IBA network will hopefully address the first issue here but separate attention should focus on adopting new sites under the Ramsar Convention. The efficacy of site prioritisation work within a highly mobile system is hard to ascertain but a precautionary approach that assumes SBS may not be capable of shifting sites regularly should be adopted until local and seasonal movements are understood.
- To understand the impact of hunting on shorebirds in Bangladesh, a large sample of structured interviews should be collected with a process for conducting awareness-raising in hunting hotspots afterwards, ideally with local staff trained to continue this work. This work should build off an awareness-raising and advocacy campaign conducted by MarineLife Alliance under the CWBMP in 2008–2009 around Sonadia.
- Ongoing strengthening of institutional and logistic capacity within Bangladesh will facilitate the implementation of future research and conservation actions; BirdLife International is currently investigating how best to support local conservation capacity (M. Crosby pers. comm. 2010).

It is important to reiterate that these few conservation recommendations supplement a comprehensive list of possible actions identified by Zöckler *et al.* (2008). We have concentrated on first identifying the research needs that can help to prioritise between that longer list of

potential conservation actions under the headings of species protection, habitat protection, site management, habitat and site restoration, awareness-raising and education and capacity building (as in Zöckler *et al.* 2008). A clearer understanding of the status, movements and trends of SBS is a start-point rather than an end-point for the recovery of SBS populations in Bangladesh. Nationally and globally a long-term strategy will be reliant on the effective implementation of targeted conservation actions, prioritised according to urgency, potential returns and cost.

CONCLUSION

Our survey indicates that Bangladesh remains a critical wintering area for Spoon-billed Sandpipers and suggests that incomplete survey coverage to date might explain a reduction in reporting rate of SBS, although this requires further study (see recommendations above). It also reinforces the notion that SBS displays a degree of relatively high habitat specificity for a calidrine wader and indicates that hunting may still be a threat to its long-term survival. Given the species's precarious position, there is an urgent need for conservation interventions now as outlined by the action plan and in this paper. Our recommendations list the key research priorities for SBS in Bangladesh in the coming years. Lack of funding to conduct the necessary research and implement conservation actions risks compromising the species's long-term survival. If the number of people paying to visit Thailand in recent years fuelled by a 'last chance to see' mentality is any indication of the interest in and enthusiasm for this enigmatic wader, it would be nice to believe that it is possible to mobilise sufficient financial resources to tackle the most pertinent threats through research and conservation actions.

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